Frogs using cossid moth galleries: an opportunity in Flooded Gum plantations in the New South Wales North Coast bioregion

Matthew Mo

Forest Science Centre, NSW Department of Primary Industries, PO Box 242, Parramatta NSW 2151

Current address: State Veterinary Diagnostic Laboratory, NSW Department of Primary Industries, Elizabeth Macarthur Agricultural Institute, Woodbridge Road, Menangle NSW 2568

Email: matthew.mo@dpi.nsw.gov.au

ABSTRACT

Surveys of the impact of stem-boring insects were carried out across 14 Flooded Gum *Eucalyptus grandis* plantations in the New South Wales North Coast bioregion. This paper reports on novel observations made during this work of the Bleating Tree Frog *Litoria dentata* seeking refuge in cossid moth galleries. On four occasions, frogs were found in Giant Wood Moth *Endoxyla cinereus* galleries, which occurred in more than 10% of trees in the entire study. The incident of damage caused by a second cossid species, the Culama Wood Moth *Culama australis* was far lower (0.2%), with only one frog observed in a gallery excavated by this species. These structures make reasonable retreat sites for arboreal frogs because they are generally inaccessible to larger predators by being located off the ground and having narrow entrances.

Key words: amphibian, Cossidae, *Endoxyla cinereus,* eucalypt plantation, *Litoria dentata*, retreat sites

DOI: http://dx.doi.org/10.7882/AZ.2015.010

Introduction

The Bleating Tree Frog *Litoria dentata* Keferstein (Anura: Hylidae) is a small amphibian that occurs along the slopes of the Great Dividing Range and coastal areas from southern Queensland (Tyler and Knight 2011) to East Gippsland, Victoria (Gillespie and Kum 2011). They are found in a variety of habitats, including wet and dry sclerophyll forest, rainforest (Cogger 2014), open woodland (Ferraro and Burgin 1993) and urban areas (White and Burgin 2004). This species usually breeds in ephemeral swamps and lagoons following spring and summer rainfall (Greer and Mills 1998; Anstis 2002). Despite being locally common (Hero *et al.* 2006), the Bleating Tree Frog has been subject to few studies, with limited information available on its basic biology.

Tree frogs (genus *Litoria*) exploit a variety of natural and artificial retreat sites. Gibbons and Lindenmayer (2002) list seven Australian species as using tree hollows; while a further 17 species are recognised as potential hollow-users, including the Bleating Tree Frog. Exfoliating bark also provides arboreal shelter during the day (Barker *et al.* 1995; Bilusich *et al.* 2009). Tree frogs have also been recorded beneath rocks (Gillespie and Hollis 1996; Murphy 1997; Heard *et al.* 2008) and timber debris (Lunney and Barker 1986; Murphy 2008) or in rock crevices (Reynolds 2005; Doughty and Anstis 2007). Some species seek shelter nestled amongst ground vegetation (Pyke and White 2001) or leaf litter (Parris 2001), whilst others remain camouflaged in exposed positions during rest (Mo 2015). Artificial microhabitats include toilet blocks and rainwater tanks (Watson and Gerhardt 1997; Wabnitz *et al.* 2009; Mo 2014).

While an immature eucalypt plantation is unlikely to have many of the retreat opportunities mentioned above, the susceptibility of plantation trees to native stem-boring insects may present a unique opportunity for tree frogs. Flooded Gum *Eucalyptus grandis* occurs naturally along the east coast of Australia between Atherton, Queensland, and Newcastle, New South Wales (NSW) (Arnold *et al.* 1996), and is cultivated in plantations within this range (Turner and Lambert 1983; Cromer 1993). This species, however, is susceptible to damage from cossid moths (Family Cossidae) (King and Lawson 2005; Carnegie *et al.* 2008; Debuse and Lawson 2010; Nichols *et al.* 2010). Notably, the larvae of the Giant Wood Moth *Endoxyla cinereus* excavate galleries into tree trunks (Fig. 1), apparently targeting regions of smooth bark (McInnes and Carne 1978). This paper reports on incidental observations of Bleating Tree Frogs exploiting cossid galleries in the NSW North Coast bioregion.

Methods

The observations reported here were made during fieldwork between July 2012 and October 2013 for a broader project, which focused on the impact of stem defect agents in Flooded Gum plantations in north-eastern NSW (Lawson *et al.*, unpubl. data).

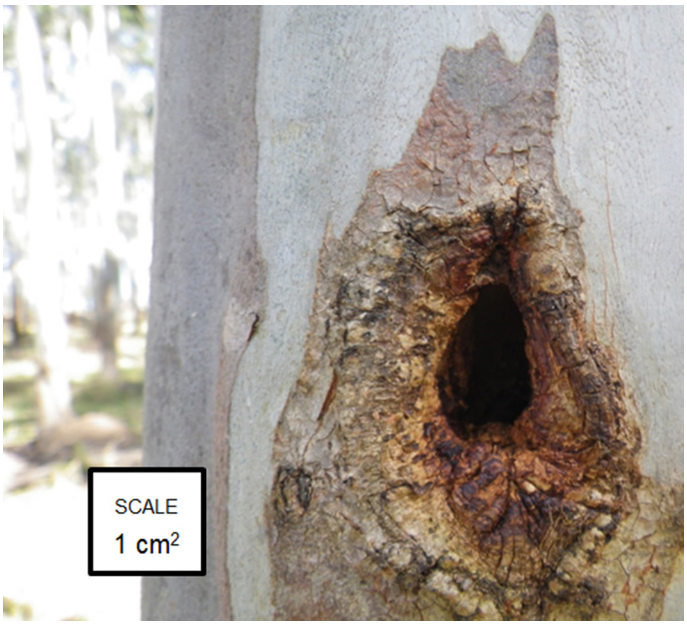

Figure 1. A disused Giant Wood Moth *Endoxyla cinereus* gallery on an immature Flooded Gum *Eucalyptus grandis* (13.4 cm DBH). Photo, M. Mo.

Study sites

Visits were made to 14 Flooded Gum plantations between Taree and Byron Bay (Table 1; Fig. 2). All the sites were first-rotation plantations, 10-15 year old, that had been established on cleared agricultural land on undulating terrain. Three sites were well-maintained with no vegetation between the tree plantings (Fig. 3). Others were inundated by stands of native grasses, sedges, ferns and wattle (6 sites), or by the exotic weeds Lantana *Lantana camara* (3 sites; Fig. 4) and Camphor Laurel *Cinnamomum camphora* (2 site). Except for the Collombatti plantation, all sites had water bodies, with streams flowing through the site or beside rivers (43% of sites), farm dams (5% of sites) and ephemeral pools (22% of sites) in valleys below the plantations.

Field surveys

Twenty-one circular plots of 10 trees were assessed for damage by stem defect agents, providing a sample size of 210 trees per site. These plots were selected from 45 random points that were generated using Geospatial Modelling Environment (Beyer 2014). Field surveys targeted both cossid moths and longicorn beetles (Family Cerambycidae); however this paper only focuses on excavations made by the former. These were identified by a number of characteristic signs: an accumulation of coarse frass at the base of an affected tree, a tent-like cap of frass over an entrance hole, swelling in the tree trunk, and/or a prominent emergence hole in disused galleries (Carnegie *et al.* 2008).

The number of trees exhibiting cossid galleries within the lower 4 m of the trunk was recorded. Suspect cossid damage was exposed by gently removing decomposing wood with a screwdriver and the identity of insect taxa was confirmed by observing the structures beneath. For disused galleries, a 210-lumen torch was shone into the main chamber enabling the main chamber to be viewed for other fauna, including frogs (Fig. 5). The limitation of this method was that parts of the gallery were not viewable (e.g. the tunnel formerly occupied

Table 1. Summary of study sites.

Extent of vegetation: ext = extensive, mod = moderate, min = minimal

Site	Location	Plantation area (ha)	Vegetation between plantings	Survey dates
Argents Hill	S-30.6373, E152.7477	13.4	none	17-18 December 2012, 10-12 February 2013
Bexhill	S-28.7470, E153.3710	20.0	Lantana (ext)	8-10 February 2013
Birdwood	S-31.3671, E152.3260	48.9	Native (min)	17-19 August 2012, 9 October 2013
Bucca	S-30.1417, E153.1021	12.6	Camphor Laurel (ext)	18-20 October 2012
Collombatti	S-30.9940, E152.8007	47.7	Native (min)	20-21 November 2012
Coraki	S-28.9668, E153.2085	29.8	none	26-28 July 2012
Coutts Crossing	S-29.8700, E152.9333	12.3	none	17-18 February 2013
Eungai Rail	S-30.8486, E152.8921	17.1	Native (min)	12-14 December 2012
Geneva	S-28.6428, E152.9594	20.7	Lantana (mod)	29-30 July 2012
Hollisdale	S-31.3961, E152.5408	12.8	Lantana (ext)	14 August, 11-12 December 2012, 7-8 October 2013
Kew	S-31.6164, E152.7309	35.8	Native (mod)	14-16 August 2012
Lawrence	S-29.4971, E153.1400	16.2	Native (mod)	1-2 August 2012
Lowanna	S-30.2010, E152.9231	17.3	Native (mod)	21-23 October 2012
Nana Glen	S-30.1019, E153.0149	27.4	Camphor Laurel (ext)	15-17 December 2012

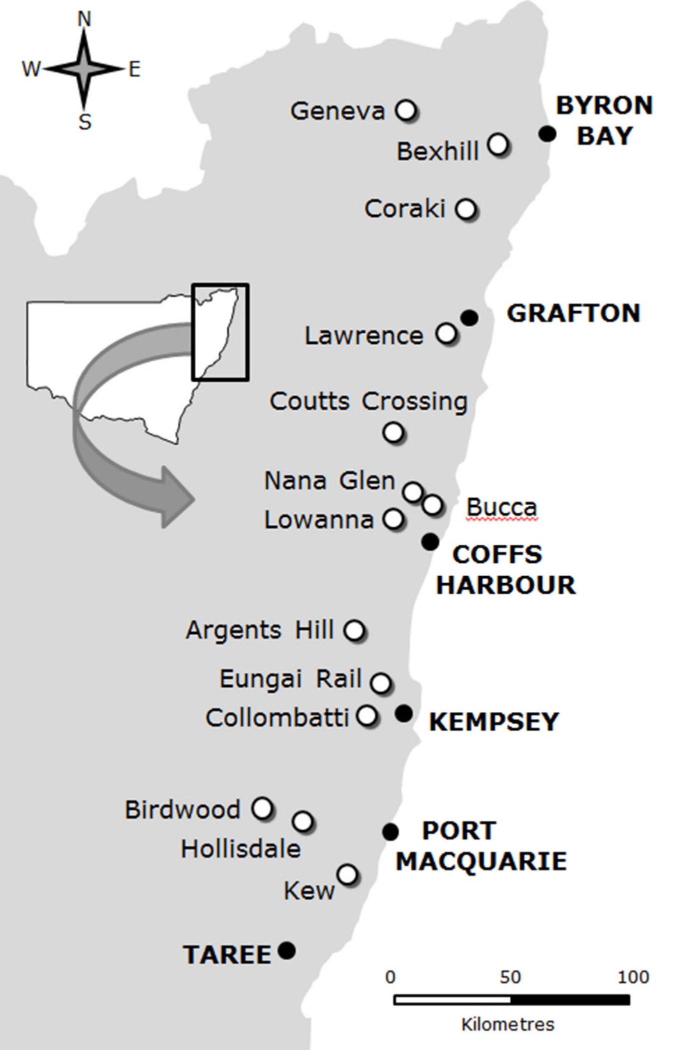

Figure 2. Locations of the 14 study sites in the NSW North Coast bioregion.

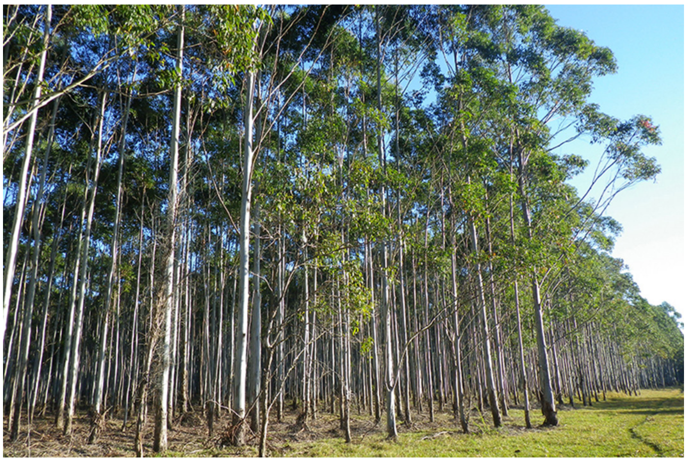

Figure 3. Flooded Gum *Eucalyptus grandis* growing in a first-rotation plantation in Coraki. This site is an example of a plantation with no understorey growth. Photo, M. Mo.

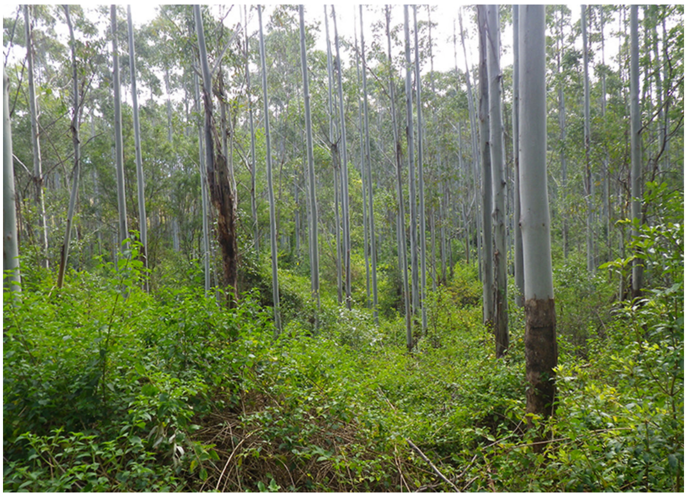

Figure 4. A plantation in Hollisdale, which has an extensive understorey of Lantana *Lantana camara*. Photo, M. Mo.

by the pupa). Cossid galleries that had been opened up by feeding cockatoos (McInnes and Carne 1978) were also recorded (Fig. 6). These represent retreat sites that are not usable by frogs because the cavity spaces have been exposed.

Results

Incidence of cossid damage

Giant Wood Moth galleries were found in 12.9% of trees in the entire study (n = 2,940). Incidence at each site ranged from eight (4%) to 51 (24%) affected trees (n = 210) (Table 2). Most affected trees exhibited only a single gallery, although at least one fifth of affected trees suffered multiple attacks. Moth galleries seldom exhibited emergence holes wider than 2 cm (Fig. 1). In others, the internal structures were exposed by feeding cockatoos (Fig. 6). The damage caused stems to be completely snapped off in a minority of cases. The proportion of galleries opened up by cockatoos varied between sites (Fig. 7). The highest incidence was found at Nana Glen, where 85% of galleries had been opened up. Cockatoo-damaged galleries comprise more than 50% of galleries in five other sites (Argents Hill, Bexhill, Collombatti, Coutts Crossing and Lowanna). No evidence of cockatoo damage was observed at two sites (Coraki and Kew).

Incidence of damage caused by a second cossid, the Culama Wood Moth *Culama australis* (Table 2; Fig. 8) was far lower. This was observed on three trees in Coraki and two trees in Eungai Rail (0.2%, n = 2,940 trees). In two cases, pupae were discovered upon probing beneath decomposing bark. The most extensive gallery was recorded in Coraki, which occupied half the circumference of the tree (162 cm) and 112 cm of height. The remainder occurred on smaller trees with damage heights ranging between 50 and 90 cm.

Observations of retreating frogs

Seven Bleating Tree Frogs, all adult sized (>3 cm, snout-vent length) were observed using cossid moth galleries during the study (Table 2). There were four Giant Wood Moth galleries occupied by frogs; three at Coraki (26, 28 July 2012) and one at Hollisdale (11 December 2012). In one of these, at least three frogs were observed clinging vertically to the back wall of the main chamber.. The other galleries each contained one frog.

Frogs exploited 14% of available Giant Wood Moth galleries in Coraki, and 2% in Hollisdale (Fig. 9). None of the galleries in Coraki were damaged by cockatoos; however cockatoo damage in Hollisdale reduced the availability of suitable galleries by 33%. In all observations of retreating frogs, the galleries were between 1.3 and 1.6 m off the ground, and moisture was observed on the walls of the galleries.

Culama Wood Moth galleries were far less common (Table 2), and only one frog was observed retreating in one of these (Fig. 10). The observation was made in Coraki on 28 July 2012, in the large gallery described above (Fig. 8). The frog was discovered upon peeling away soft necrotic bark off the gallery site. It was located at the top right-hand corner of the gallery, below a section of live bark. The frog was facing downwards with its head lifted off the wood surface, so presumably it was disturbed from a resting posture during peeling. The cavity width where it was found was between 7 and 11 mm.

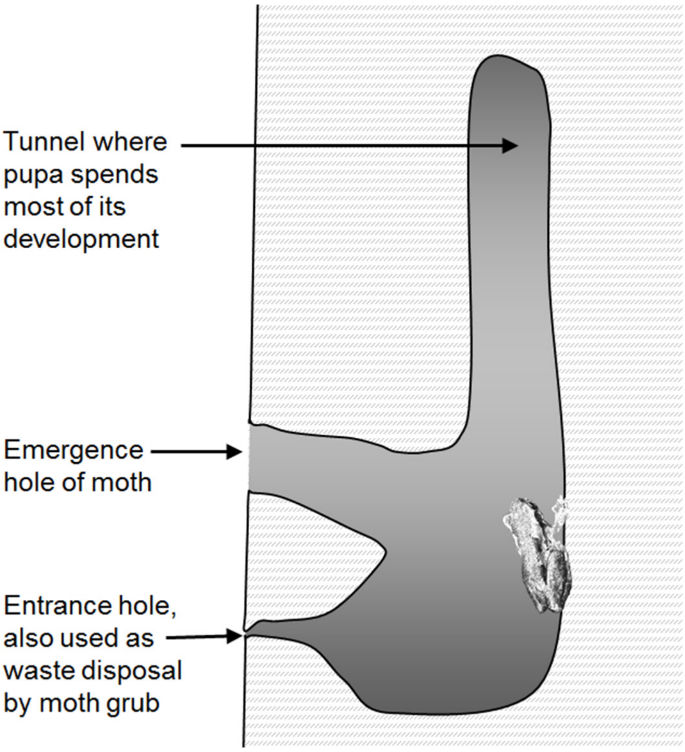
Tunnel where pupa spends most of its development
Emergence hole of moth
Entrance hole, also used as waste disposal by moth grub

Figure 5. A diagrammatic cross section of a Giant Wood Moth *Endoxyla cinereus* gallery, illustrating the physical limitations of examining the structure externally by the emergence hole. Only the side and back walls of the main chamber can be effectively viewed.

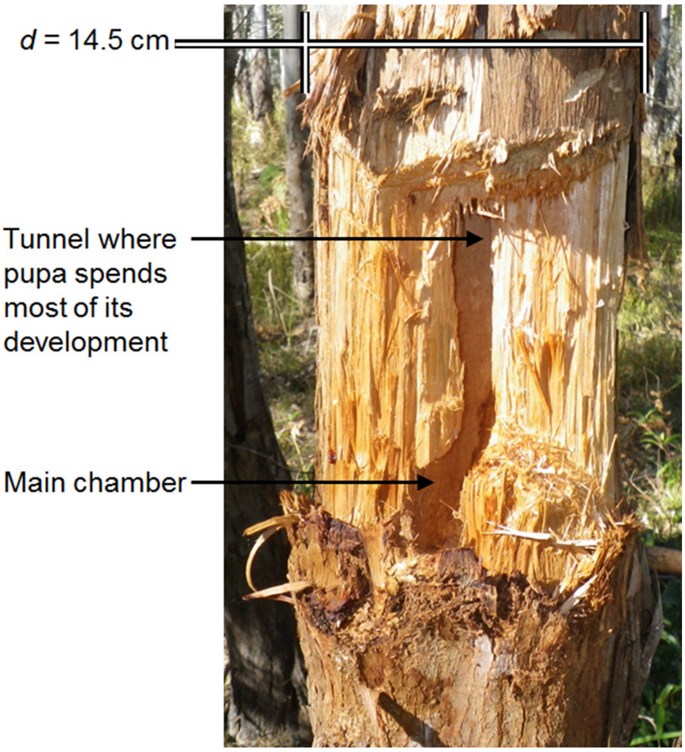

Figure 6. A rough transverse section of a Giant Wood Moth *Endoxyla cinereus* gallery made by a cockatoo extracting the pupa, showing the main chamber and the tunnel that the pupa resided in. Photo, M. Mo.

Table 2. Incidence of trees affected by Giant and Culama Wood Moth galleries, and cockatoo attack at 14 study sites. The number of galleries occupied by frogs is also provided.

	Giant Wood Moth		Culama Wood Moth
	No. affected trees (%)	No. opened up by cockatoos	No. affected trees
Argents Hill	33 (15.7)	22	0
Bexhill	37 (17.6)	27	0
Birdwood	51 (24.3)	2	0
Bucca	17 (8.1)	8	0
Collombatti	39 (18.6)	21	0
Coraki	21 (10.0)	0	3
Coutts Crossing	33 (15.7)	20	0
Eungai Rail	35 (16.7)	16	2
Geneva	18 (8.6)	2	0
Hollisdale	48 (22.9)	16	0
Kew	8 (3.8)	0	0
Lawrence	10 (4.8)	1	0
Lowanna	10 (4.8)	7	0
Nana Glen	17 (8.1)	17	0

Discussion

The novel observations presented in this paper describe a form of refuge for Australian arboreal frogs not previously reported. Natural hollows in eucalypt trees may require between 100 and 400 years to form (Ambrose 1982), so would be expected to be absent or occur at very low rates in 30-year rotation plantations. Cossid galleries may represent a practicable substitute to natural hollows for small vertebrates such as tree frogs in these anthropogenic settings.

The results of this study suggest that although the exploitation of cossid galleries by frogs may be infrequent, cossid galleries may make reasonable retreat sites for a number of reasons, including their defensive properties. Not only are these structures located off the ground, they possess narrow entrances, typically on smooth bark, making internal chambers inaccessible to larger predators. Birds and most mammals are unable to prey on the sheltered frogs unless excavation is undertaken. In addition, the more centrally located position of Giant Wood Moth galleries possibly offers superior protection in the event of wildfire than cavities beneath exfoliating bark or Culama Wood Moth galleries.

Like natural hollows, Giant Wood Moth galleries act as a point of water collection (Ambrose 1982; Jenkins and Kitching 1990), which could make them more attractive to frogs than sheltering beneath exfoliating bark. In addition, the entrance hole bored by the pupa potentially provides a small outlet for water, offsetting stagnation. Being semi-enclosed, Giant Wood Moth galleries, like tree hollows, are likely to have a higher relative humidity than ambient surroundings (McComb and Noble 1981), and be buffered from temperature fluctuations and extremes, which may be beneficial to frogs in hot or dry climates (Gibbons and Lindenmayer 2002).

The low incidence of trees affected by Culama Wood Moth was unexpected. Flooded Gum is known to be highly susceptible to their attacks, especially pure stock (Carnegie *et al.* 2008). Despite its scarcity, this gallery type is available to frogs irrespective of the moth larval stage. The Giant Wood Moth pupa bores its emergence hole only at the end of its stay in the gallery (McInnes and Carne 1978), so these galleries are not accessible to frogs until this time. In contrast, Culama Wood Moth galleries are never fully enclosed and numerous larval stages may be present at any time (Carnegie *et al.* 2008). These galleries are more vertically compressed and their use by frogs may more closely resemble retreating beneath exfoliating bark.

Unless a tree affected by a Giant Wood Moth gallery dies, frogs have a limited period of time in which to exploit the structure. The time period for Flooded Gum to recover from a Giant Wood Moth attack is not known at present, however an unaffected tree was re-examined 14 months later and found to carry a healed emergence hole (pers. obs). This isolated observation suggests that within this time frame, a tree may house a pupa and mostly complete healing. In this

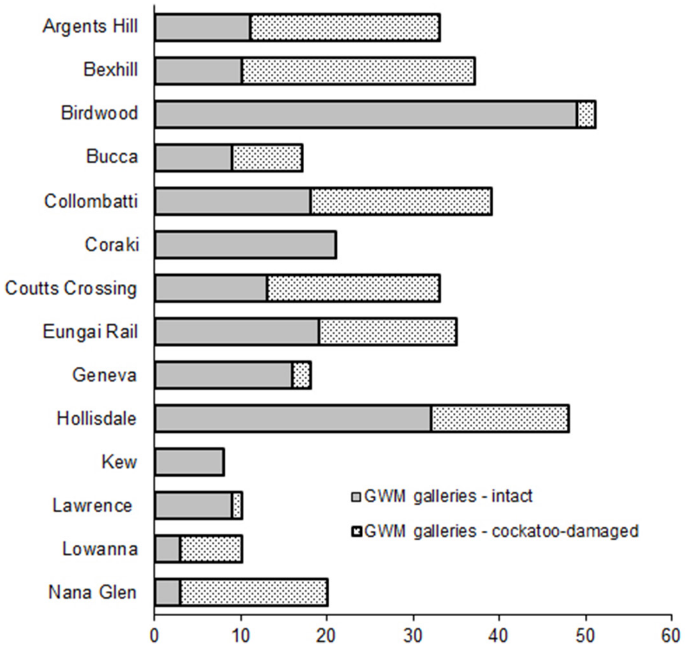

Figure 7. Number of trees affected by Giant Wood Moth galleries at 14 study sites, including the proportion of those damaged by cockatoos.

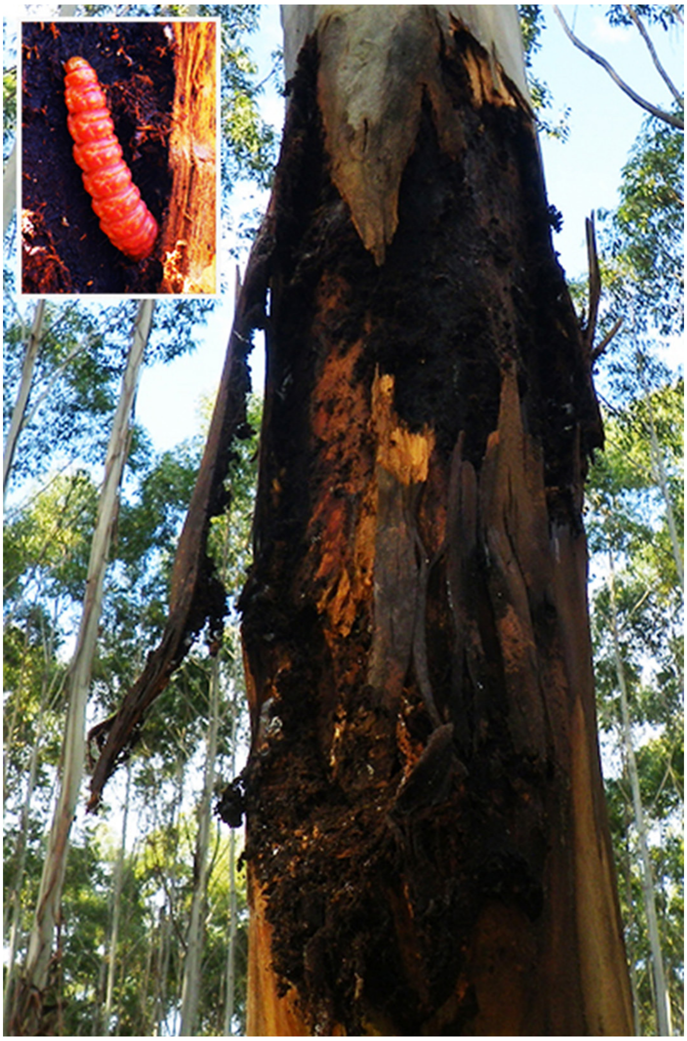

Figure 8. An incidence of damage caused by a Culama Wood Moth *Culama australis* recorded in Coraki, and a pupa exposed from its chambers in Eungai Rail (inset). Photos, M. Mo.

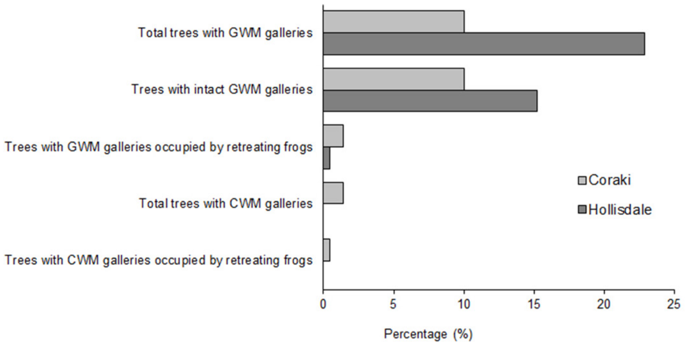

Figure 9. Incidence of Bleating Tree Frogs *Litoria dentata* retreating in Giant (GWM) and Culama Wood Moth (CWM) galleries in Coraki and Hollisdale, and the availability of these structures.

case, the empty pupal case was enclosed between the healed bark, indicating the speed of recovery.

There has been some concern for the persistence of vertebrate fauna in plantation areas (Lindenmayer and Hobbs 2004; Kanowski *et al.* 2005), particularly reductions in opportunities for retreat sites and other ecological needs in a landscape monoculture. The observations in this paper add to the study of arboreality in Australian frogs (Gibbons and Lindenmayer 2002), confirming the use of tree cavities in the Bleating Tree Frog. Despite the threat cossid moths pose to the market value of timbers, their presence in production estate offer potential benefits to tree frogs and other fauna.

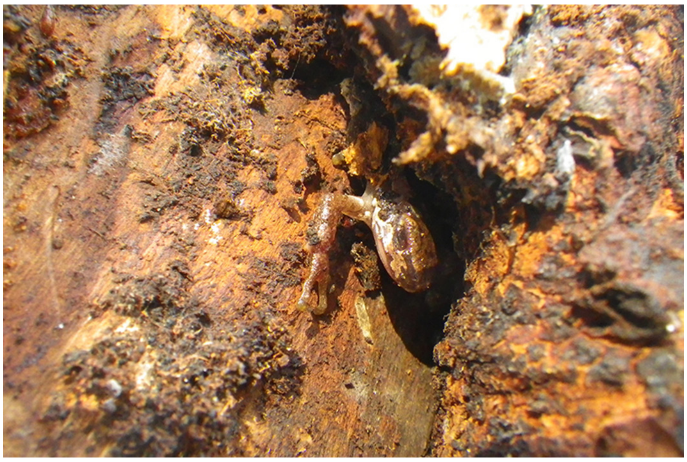

Figure 10. A Bleating Tree Frog *Litoria dentata* discovered behind the necrotic bark of a Culama Wood Moth gallery. Photo, M. Mo.

Acknowledgements

I thank Angus Carnegie and Christine Stone for the opportunity to carry out this study during a broader project that was jointly undertaken between NSW Department of Primary Industries and Queensland Department of Agriculture, Fisheries and Forestry. Thanks also to Matt Nagel, Martin Horwood and Scott Swift who were present in the field surveys, Brad Law and Martin Predavec for useful discussions and two anonymous reviewers for their helpful comments.

References

Ambrose, G.J. 1982. *An Ecological and Behavioural Study of Vertebrates Using Hollows in Eucalypt Branches*. PhD thesis. La Trobe University, Melbourne.

Anstis, M. 2002. *Tadpoles of South-Eastern Australia*. Reed New Holland, Sydney.

Arnold, R.J., Burgess, I.P. and Allender, E.B. 1996. *Eucalyptus grandis* seed source variation for growth and form in the southern Murray-Darling Basin. *Australian Forestry* **59**: 114-119.

Barker, J., Grigg, G.C. and Tyler, M.J. 1995. *A Field Guide to Australian Frogs*. Surrey Beatty and Sons, Chipping Norton, NSW.

Beyer, H.L. 2014. *Geospatial Modelling Environment*. http://www.spatialecology.com/gme

Bilusich, D., Jackway, R.J., Musgrave, I.F., Tyler, M.J. and Bowie, J.H. 2009. The host-defence skin peptide profiles of Peron's Tree Frog *Litoria peronii* in winter and summer. Sequence determination by electrospray mass spectrometry and activities of the peptides. *Rapid Communications in Mass Spectrometry* **23**: 2628-2636.

Carnegie, A., Lawson, S., Smith, T., Pegg, G., Stone, C. and McDonald, J. 2008. *Healthy Hardwoods: A Field Guide to Pests, Diseases and Nutritional Disorders in Subtropical Hardwoods*. Forest and Wood Products Australia, Melbourne.

Cogger, H.G. 2014. *Reptiles and Amphibians of Australia*. 7th edn. CSIRO Publishing, Collingwood, Vic.

Cromer, R.N., Cameron, D.M., Rance, S.J., Ryan, P.A. and Brown, M. 1993. Response to nutrients in *Eucalyptus grandis*. 1. Biomass accumulation. *Forest Ecology and Management* **62**: 211-230. http://dx.doi.org/10.1016/0378-1127(93)90051-N

Debuse, V. and Lawson, S. 2010. Drafting landscapes into arresting insect attacks. *Australian Forest Grower* **33**: 50-51.

Doughty, P. and Anstis, M. 2007. A new species of rock-dwelling hylid frog (Anura: Hylidae) from the eastern Kimberley region of Western Australia. *Records of the Western Australian Museum* **23**: 241.

Ferraro, T.J. and Burgin, S. 1993. Amphibian decline: a case study in western Sydney. Pp. 197-204 in *Herpetology in Australia: A Diverse Discipline*, edited by D. Lunney and D. Ayers. Royal Zoological Society of New South Wales, Mosman, NSW.

Gibbons, P. and Lindenmayer, D. 2002. *Tree Hollows and Wildlife Conservation in Australia*. CSIRO Publishing, Collingwood, Vic.

Gillespie, G.R. and Hollis, G.J. 1996. Distribution and habitat of the spotted tree-frog, *Litoria spenceri* Dubois (Anura: Hylidae), and an assessment of potential causes of population declines. *Wildlife Research* **23**: 49-75. http://dx.doi.org/10.1071/WR9960049

Gillespie, G.R. and Kum, K.C. 2011. The Bleating Tree Frog *Litoria dentata* Keferstein (Anura: Hylidae): an addition to the frog fauna of Victoria. *Victorian Naturalist* **128**: 256-259.

Greer, A.E. and Mills, A. 1998. Observations on the biology of the Bleating Tree Frog *Litoria dentata* (Anura: Hylidae), made on a single population in Sydney, New South Wales. *Australian Zoologist* **30**: 383-386. http://dx.doi.org/10.7882/AZ.1998.002

Heard, G.W., Robertson, P. and Scroggie, M.P. 2008. Microhabitat preferences of the endangered Growling Grass Frog *Litoria raniformis* in southern Victoria. *Australian Zoologist*

34: 414-425. http://dx.doi.org/10.7882/AZ.2008.019

Hero, J.M., Morrison, C., Gillespie, G., Roberts, J.D., Newell, D., Meyer, E., McDonald, K., Lemckert, F., Mahony, M., Osborne, W., Hines, H., Richards, S., Hoskini, C., Clarke, J., Doak, N. and Shoo, L. 2006. Overview of the conservation status of Australian frogs. *Pacific Conservation Biology* **12**: 313-320.

Jenkins, B. and Kitching, R.L. 1990. The ecology of water-filled treeholes in Australian rainforests: food web reassembly as a measure of community recovery after disturbance. *Australian Journal of Ecology* **15**(2): 199-205. http://dx.doi.org/10.1111/j.1442-9993.1990.tb01528.x

Kanowski, J., Catterall, C.P. and Wardell-Johnson, G.W. 2005. Consequences of broadscale timber plantations for biodiversity in cleared rainforest landscapes of tropical and subtropical Australia. *Forest Ecology and Management* **208**: 359-372. http://dx.doi.org/10.1016/j.foreco.2005.01.018

King, J. and Lawson, S. 2005. Insect pests and diseases of rainforest timber species grown in plantations. Pp. 114-128 in *Reforestation in the Tropics and Subtropics of Australia Using Rainforest Tree Species*, edited by P.D. Erskine, D. Lamb and M, Bristow. RIRDC Publication No 05/087. Rural Industries Research and Development Corporation, Canberra.

Lindenmayer, D.B. and Hobbs, R.J. 2004. Fauna conservation in Australian plantation forests – a review. *Biological Conservation* **119**: 151-168. http://dx.doi.org/10.1016/j.biocon.2003.10.028

Lunney, D. and Barker, J. 1986. Survey of reptiles and amphibians of the coastal forests near Bega, NSW. *Australian Zoologist* **22**: 1-9. http://dx.doi.org/10.7882/AZ.1986.001

McComb, W.C. and Noble, R.E. 1981. Microclimates of nest boxes and natural cavities in bottomland hardwoods. *The Journal of Wildlife Management* **45**(1): 284-289. http://dx.doi.org/10.2307/3807906

McInnes, R.S. and Carne, P.B. 1978. Predation of cossid moth larvae by yellow-tailed black cockatoos causing losses in plantations of *Eucalyptus grandis* in north coastal New South Wales. *Australian Wildlife Research* **5**: 101-121. http://dx.doi.org/10.1071/WR9780101

Mo, M. 2014. A preliminary evaluation of frog assemblages in the Pilliga forests. *Wetlands (Australia)* **27**(2): 2-10.

Mo, M. 2015. Herpetofauna community of the constructed Lime Kiln Bay Wetland, southern Sydney. In press, *The Victorian Naturalist* **132**.

Murphy, M.J. 1997. Frogs at Wagga Wagga, NSW: a comparison of recent and historical records. *Herpetofauna* **27**: 7-10.

Murphy, M.J. 2008. Observations of frog activity in an area affected by intense wildfire in the Pilliga forest, New South Wales. *Herpetofauna* **38**: 71-74.

Nichols, J.D., Smith, R.G.B., Grant, J. and Glencross, K. 2010. Subtropical eucalypt plantations in eastern Australia. *Australian Forestry* **73**: 53-62.

Parris, K.M. 2001. Distribution, habitat requirements and conservation of the cascade treefrog (*Litoria pearsoniana*, Anura: Hylidae). *Biological Conservation* **99**: 285-292. http://dx.doi.org/10.1016/S0006-3207(00)00194-4

Pyke, G.H. and White, A.W. 2001. A review of the biology of the green and golden bell frog *Litoria aurea*. *Australian Zoologist* **31**: 563-598. http://dx.doi.org/10.7882/AZ.2001.003

Reynolds, S.J. 2005. Use of tree hollows by the Green Tree Frog *Litoria caerulea* at East Point Reserve, Darwin. *Northern Territory Naturalist* **18**: 61-67.

Turner, J. and Lambert, M.J. 1983. Nutrient cycling within a 27-year-old *Eucalyptus grandis* plantation in New South Wales. *Forest Ecology and Management* **6**: 155-168. http://dx.doi.org/10.1016/0378-1127(83)90019-1

Tyler, M.J. and Knight, F. 2011. *Field Guide to the Frogs of Australia*. Rev. edn. CSIRO Publishing: Collingwood, Vic.

Wabnitz, P.A., Bowie, J.H., Wallace, J.C. and Tyler, M.J. 1999. Peptides from the skin glands of the Australian buzzing tree frog *Litoria electrica*: comparison with the skin peptides of the red tree frog *Litoria rubella*. *Australian Journal of Chemistry* **52**: 639-646. http://dx.doi.org/10.1071/CH98171

Watson, G.F. and Gerhardt, H.C. 1997. The breeding biology and advertisement call of *Litoria splendida* Tyler, Davies and Martin. *Transactions of the Royal Society of South Australia* **121**: 119-124.

White, A.W. and Burgin, S. 2004. Current status and future prospects of reptiles and frogs in Sydney's urban-impacted bushland reserves. Pp. 109-123 in *Urban Wildlife: More than Meets the Eye,* edited by D. Lunney and S. Burgin. Royal Zoological Society of New South Wales, Mosman NSW.